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AFATL-TR-68-115

AD 500065

**Test of the Fragmenting Directional
Warheads Against Trees (U)**

by

John F. Black

TECHNICAL REPORT AFATL-TR-68-115

SEPTEMBER 1968

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**AIR FORCE ARMAMENT LABORATORY
AIR FORCE SYSTEMS COMMAND
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TEST OF FRAGMENTING DIRECTIONAL WARHEADS AGAINST TREES (U)

By

John F. Black

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FOREWORD

(U) In November 1967 the Air Force Armament Laboratory received inquiries from the AFSC representative in SEA for a bomb warhead which could be carried by a helicopter and which could clear a landing area for the helicopter in a forest of 12-inch diameter trees. Two different designs in 12 variations which conceivably could be the basis for bombs were designed in-house and were fabricated by the ADTC base shops. Project 250809 was established to test one or two models of each design against trees to determine if any were worth developing. The test was simplified. It was intended that only effective designs later would be tested in facilities where complete measurements were possible.

(U) The devices found effective for tree cutting used the Mass Focus Warhead (MFW) which is described in AFATL-TR-68-86, "Studies to Exploit the Mass Focus Effect." The warhead details are not given in this report. Mr. F. E. Howard designed the test items for the project. For comparison, ADTC will report tests of pure blast bombs against trees under ADTC Project 670AW55.

(U) Information in this report is embargoed under the Department of State International Traffic In Arms Regulations. This report may be released to foreign governments by departments or agencies of the U. S. Government subject to approval of the Armament Development and Test Center (ATWT), Eglin Air Force Base, Florida 32542, or higher authority within the Department of the Air Force. Private individuals or firms require a Department of State export license.

(U) This report is classified CONFIDENTIAL because it reveals possible military applications. No classified information has been extracted from other documents.

This report is approved for publication.



CHARLES K. ARPKE, LtCol, USAF
Acting Chief, Weapons Division

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CONFIDENTIAL ABSTRACT

(C) Twelve different warheads having soft steel casings filled with type C-4 explosive were fired to cut down trees. Twelve-inch diameter mass focus warheads were effective over a 4-degree angle to 50 diameters range against trees up to 12-inch diameter. One 12-inch diameter Mass Focus Warhead [consisting of a 1-inch thick disc of explosive (7.5 pounds) between steel discs 1/8-inch thick (10 pounds)] cut all trees with maximum diameters from 5 to 9 inches within a 4 degree wedge to 80 feet from the warhead; it cut scattered small trees (2 to 4 inches) to 190 foot distance. Twenty-four-inch diameter MFWs were less effective (per unit weight) than the 12-inch designs tested. Six different hollow wall, double conical warheads were tested. These warheads had a shaped charge angle around their sides and were expected to project fragments in a sheet perpendicular to the axis. Actually, most of the energy was directed in the axial direction. These warheads made large craters and were ineffective against trees. A total of 14 shots were fired.

In addition to security requirements which must be met, this document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of the Armament Development and Test Center (ATWT), Eglin Air Force Base, Florida 32542.

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CONTENTS

Section		Page
I.	DESCRIPTION	1
II.	INSTRUMENTATION	5
III.	TEST PROCEDURES	6
IV.	TEST RESULTS	7
V.	CONCLUSIONS	14
VI.	RECOMMENDATIONS	15

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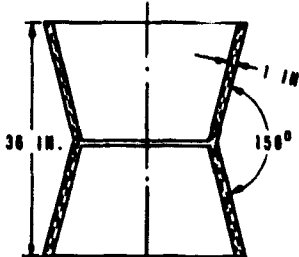
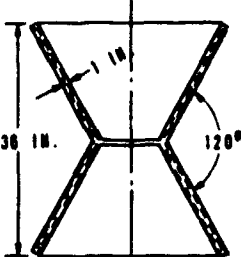
SECTION I

DESCRIPTION

(C) The conical warhead designs, which were intended to throw a sheet of fragments in directions perpendicular to the axis of symmetry, are shown in Table I. This table also gives a summary of the test results. The outer surface of all warheads in this group is a pair of cones rolled from 1/8-inch soft steel and welded. The cones are welded together at their smaller ends. The inner cones are fastened in mechanically with a small gap at the center. All were loaded with type C-4 explosive, hand packed. Table II gives a detailed description and a summary of test results for MFWs of 12- and 24-diameters made of soft steel. All had 1-inch thick C-4 explosive, hand packed. All had a 1/8-inch thick rim welded to one disc. The MFWs with 1/4-inch thick face plates had 1/8-inch deep grooves milled into the steel plates in an effort to control fragment size.

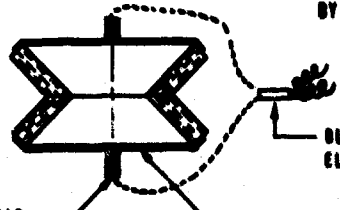
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TABLE I. DETAILED DESCRIPTION AND TEST RESULTS.

WARHEAD NUMBER	(A)	(B)
DRAWINGS OF DOUBLE CONICAL WARHEADS		
Inner cone material	steel	steel
Explosive thickness (in.)	1	1
Explosive weight (lb)	180	138
Total weight (lb)	391	325
Initiation at	ends	ends
Initiation method	"detasheet"	"detasheet"
Tested shot No.	2	1
Diameters of all trees cut (in.)	8, 12	none
Effective horizontal angle (deg)	360	none
Total wood area cut (sq in.)	163	0
Square inches of wood per pound of warhead	0.4	0

Common description: All of the conical type warheads had their outer shells made of 1/8 inch thick steel. The truncated cones were welded at the small ends. All inner cones were 1/8 inch thick and were fastened in mechanically.

SIMULTANEOUS INITIATION AT BOTH ENDS
BY DETASHEET (Dupont sheet explosive)



NON-ELECTRIC
BLASTING CAP

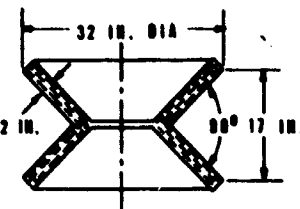

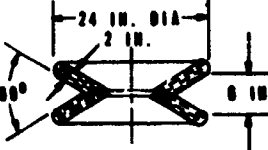
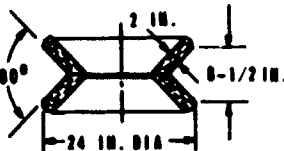
1/10 IN. THICK DETASHEET CONNECTED
TO C-4 ALL AROUND THE EDGES.

BLASTING CAP,
ELECTRIC

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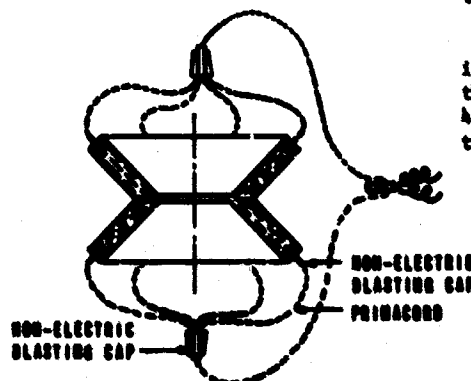
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TABLE I (Continued)

C	D	E	F
			
aluminum 2 235 326 center "primacord" 10 6, 10, 5, 4, 11, 4 360 27 0.8	aluminum 6 100 124 center "primacord" 3 none 0 0	aluminum 2 136 172 center "primacord" 12 5, 4, 6, 7 360 99 0.6	aluminum 2 127 180 ends "primacord" 4 8 360 50 0.3

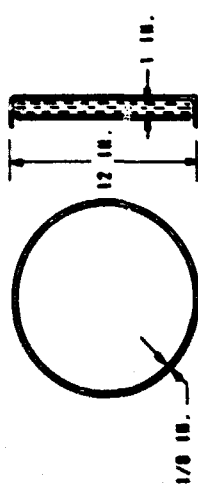
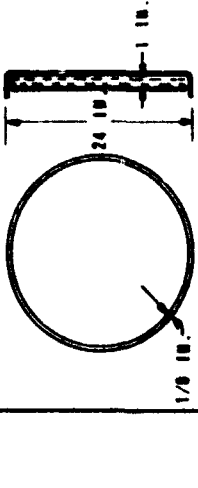

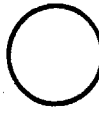

SIMULTANEOUS INITIATION AT BOTH ENDS BY PRIMACORD

One electric blasting cap initiates two primacords, each of which initiates 4 primacords connected to non-electric blasting caps in the explosive. For initiation at center, one electric cap initiates 4 equal-length primacords connected to non-electric caps struck into the explosive through the gap between the inner cones.



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TABLE II. DETAILED DESCRIPTION AND TEST RESULTS CONTINUED.

DRAWINGS OF BLAST FOCUS BURSTHEADS												
	1/8 steel	1/4 steel	1/4 steel	1/8 steel	1/8 steel	1/8 steel	1/4 steel	1/4 steel	1/4 steel	1/8 steel	1/8 steel	1/8 steel
Face plate metal thickness (in.)	7.5	7.5	7.5	7.5	7.5	7.5	27	27	27	27	27	27
Explosive weight (lb)	25.5	25.5	25.5	25.5	25.5	25.5	96	96	96	83	83	83
Total weight (lb)	1	1	1	1	1	1	1	1	1	1	1	1
Groove pattern	I	I	I	I	I	I	I	I	I	I	I	I
Tested shot No.	8	5	5	5	5	5	6	6	6	7	7	7
List of all trees cut by diameter (in.)	18, 8, 2, 4, 5, 5, 6, 8, 19,	2, 10, 6, 12, 7, 4, 2, 11	8	17, 29(1/8), 17(1/3)	4(3), 5(3), 2.3, 2.3, 1.5, 4 part	16, 15, 6, 6, 2, 2, 3, 3, 10, 10	24, 4, 4, 5, 3, 2, 5, 3, 7	12, 15, 15, 24, 17, 5, 5, 3, 7	12, 15, 15, 24, 17, 5, 5, 3, 7	12, 15, 15, 24, 17, 5, 5, 3, 7	12, 15, 15, 24, 17, 5, 5, 3, 7	12, 15, 15, 24, 17, 5, 5, 3, 7
Effective horizontal angle (deg)	5	MM	MM	MM	MM	MM	13	13	13	5	5	5
Total wood area cut (sq in.)	58	38	50	328	270	651	555	555	555	1225	1225	1225
Square inches per pound of warhead	27	15	2	17	15	6.8	5.8	5.8	5.8	14.8	14.8	14.8
Groove pattern for fragment control.												
  												
IV - Plain with 2 pounds of hard concrete nails glued to one side. V - Plain with 30 pounds of steel blocks .25 x .25 x .50 inch glued to one side. (See Figure 4A.)												

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SECTION II

INSTRUMENTATION

(U) Black and white motion pictures were taken at 4000 frames per second on 16mm film of shots 11, 12, 13, and 14. The cameras were 85 feet from the warhead for shot 14 and 200 feet for the others. While the pictures did not stop fragment motion, they were useful because bright streaks about 2 to 3 feet long could be seen which showed the direction of motion of the fragments. The pictures did not reveal the mechanism by which the fragments cut the wood because smoke enveloped the impact area within 30 frames after initiation of the explosion. The fragments traveled many times further than the smoke and fire. Therefore, a camera focused on a tree more than 30 feet from the warhead could show the cutting action.

SECTION III

TEST PROCEDURES

(U) Each conical warhead was located in a cluster of trees and was suspended with its center 3 to 5 feet above the ground.

(U) Each MFW was supported on a stake with its center 2 to 4 feet above the ground. The center of the warhead was placed on a direct line between the centers of two trees, and one face plate was aimed, by use of a mirror on the plate, directly at one tree. Warheads were tested where trees were grouped into lines.

(U) Still (black and white) pictures were taken before and after each shot. Shots 11 - 14 were photographed by high speed motion picture cameras and were fired electrically. Shots 1 - 10 had no motion picture coverage, and since timing was not required, they were fired with blasting time fuzes and nonelectric blasting caps. The procedure, requiring no circuit checking, was much faster.

(U) One MFW had one face aimed at trees and the other face aimed at the center of a wall of celotex bundles 3 feet high, 3 feet thick, and 20 feet long. Some fragments were recovered, and the horizontal angle of fragment spread was measured.

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SECTION IV

TEST RESULTS

(C) Tree cutting results are summarized in Tables I and II. The conical warheads made large craters in the ground but were ineffective for cutting trees. Typical crater size was 8 feet long by 10 feet wide by 4 feet deep. Holes in the trees showed that fragments from the conical warheads were widely dispersed. The few fragments which were dug out of the wood had penetrated 2 to 4 inches. Typical fragment size was $1/8 \times 1/4 \times 1/2$ inch. Shot 2 (model A) was best of the conicals, which indicated that a cylinder might be the correct shape for a hollow wall warhead.

(C) The MFWs focused almost all their energy into a cone of 3 degrees total angle around a line normal to the face plates. As evidence of this, the stake which supported an MFW was only half destroyed (Figure 3C). Also, the rim usually broke into pieces about $3/4$ inch x 6 inches which were found near the firing position. The fragment dispersion angle was measured on the plot between extreme trees cut as shown in Figures 1 and 2. It appears that the apex angle of the fragment cone is initially 3 degrees and that the larger angles observed are due to deflected fragments. There was clear evidence in shot 6 that individual fragments cut through more than one tree.

(C) Plots and photographs of trees felled and damaged by two different 24-inch MFWs are shown in Figures 1 and 4. Figures 2 and 3 give the plot and pictures of trees cut by one 12-inch MFW.

(C) One can estimate the minimum number of MFWs needed to cut all trees in a circular area of radius equal to the effective range by dividing 180 degrees by 3 degrees, since each warhead fires in opposite directions.

(C) The few fragments recovered were graded as follows: None of the $1.25 \times 1.25 \times .25$ inch square pieces from shot 9 were found. Probably these face plates did not break on the grooves.

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(C) Only 27 fragments from the .25-inch thick face plates grooved at .37-inch intervals (shots 5, 6, 7, and 8) were found. Size distribution was:

Length (in.)	3 - 4	2 - 3	1.5 - 2	1-1.5	.5-1	0 - .5
Number	1	3	3	10	6	4

Of these, 4 were approximately 1 inch x 1.5 inch x .25 inch and had broken across the grooves and not in the grooves. Most of the above fragments were recovered from shot 7 which was fired at celotex bundles. The fragments from an MFW having 1/8-inch face plates were recovered from trees and graded as follows:

Size (in.)	.7 x 2	.5 x 1.5	.5 x 1	.5 x .7	.2 x 1.3	.5 x .5
Number	1	2	10	12	2	8
Size (in.)	.4 x .5	.2 x .3	.1 x .15 x .06		smaller	
Number	14	12	40		50	
Size (in.)	Concrete nail fragments 1 inch long					
Number	7					

(C) Qualitatively, this data shows that for the MFW, the 1/8-inch thick face plates are about as effective as 1/4-inch thick plates when used with 1-inch thick explosive. The larger fragments retain effective velocity to distances where they are too scattered to cut larger trees. Evidence of this (Figure 5, shot 14) is the holes through 5- and 7-inch diameter trees at 185 feet distance from the warhead. Each hole appeared to be made by one fragment. At 170 feet and 190 feet, 2.2-inch diameter trees were felled. It is improbable that, at this distance, more than one fragment hit each tree.

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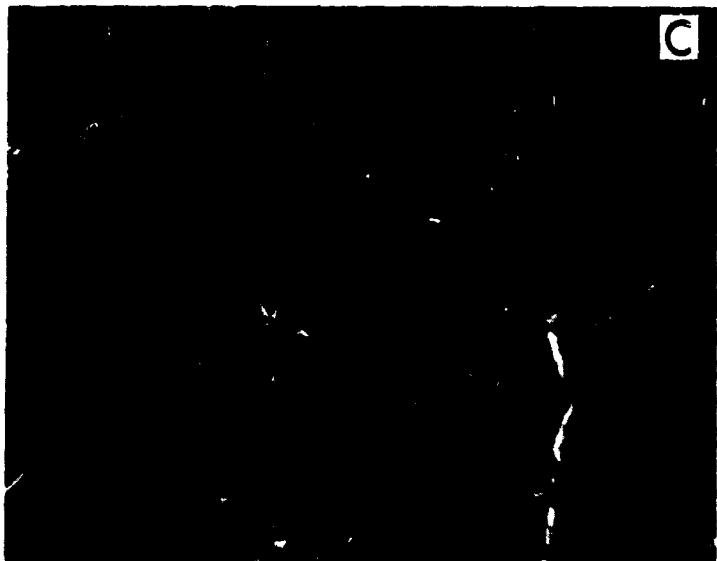
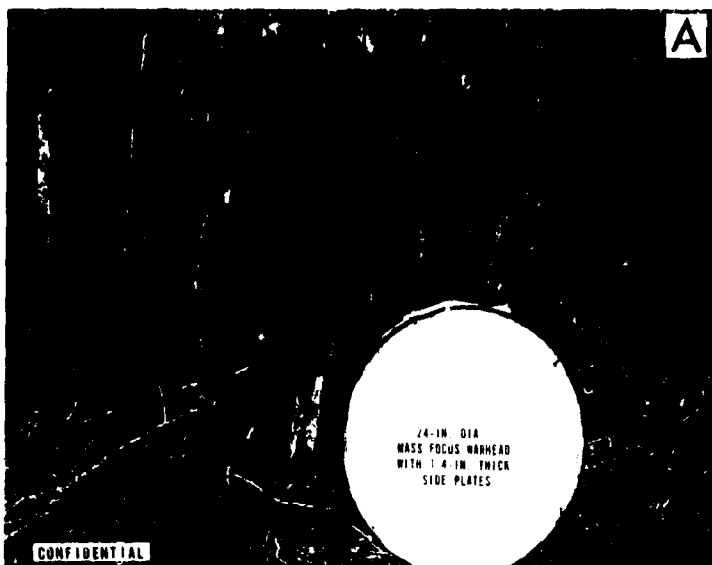
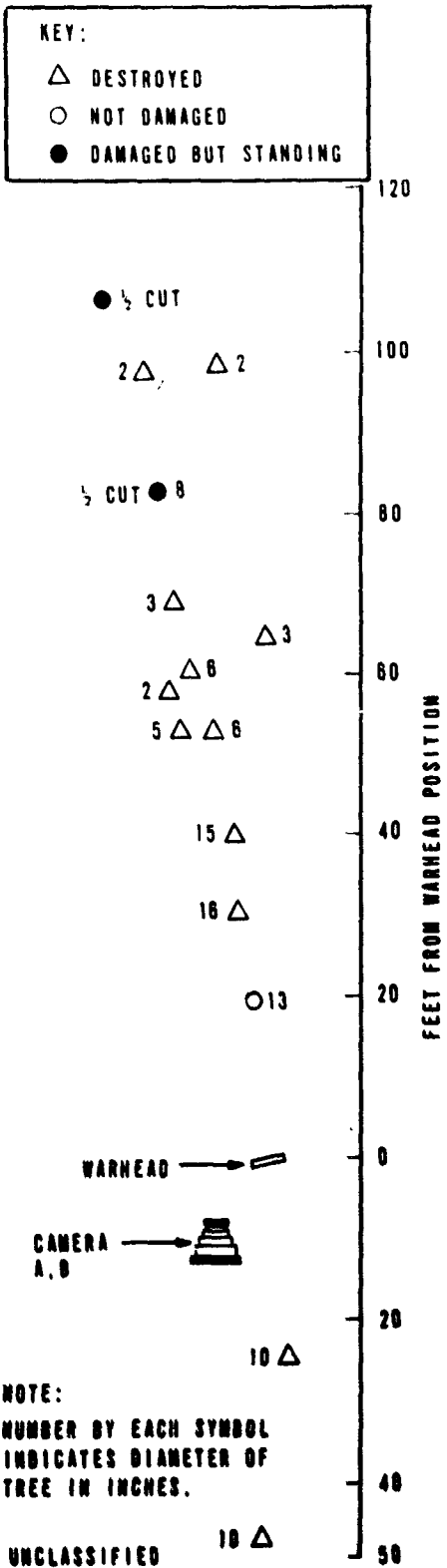


Figure 1 (Shot 6). View A shows a 24-inch MFW air View B was taken from the same position after the the opposite direction. View D is the 12-inch di ure 2) seen from the side.

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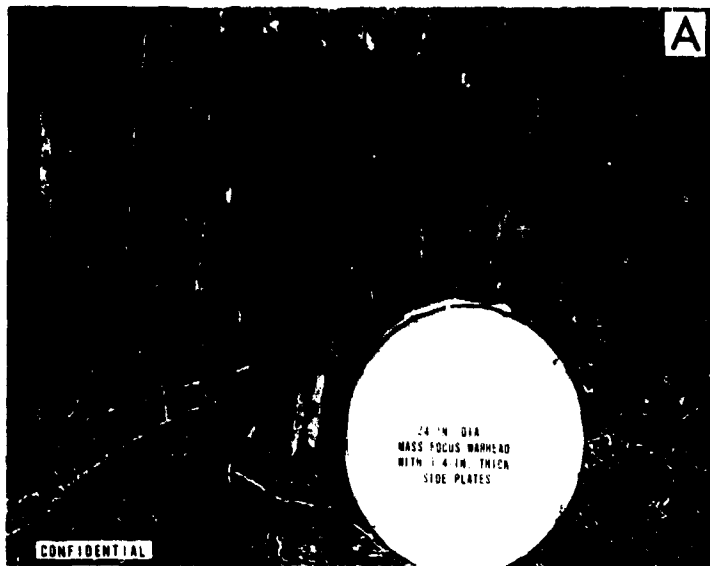


Figure 1 (Shot 6). View A shows a 24-inch MFW aimed down a column of 4 trees. View B was taken from the same position after the shot. View C was taken in the opposite direction. View D is the 12-inch diameter MFW of shot 14 (Figure 2) seen from the side.

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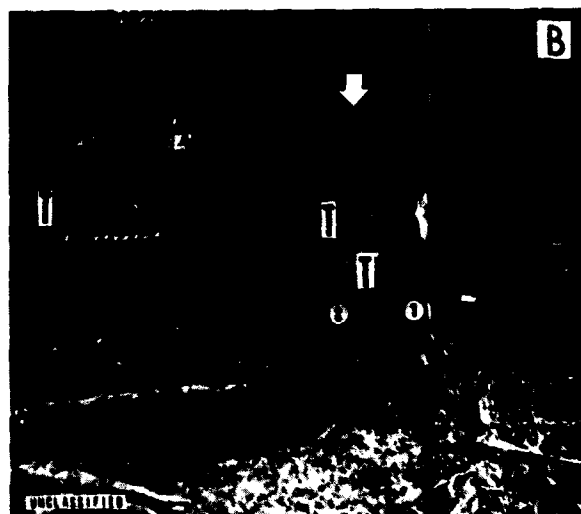
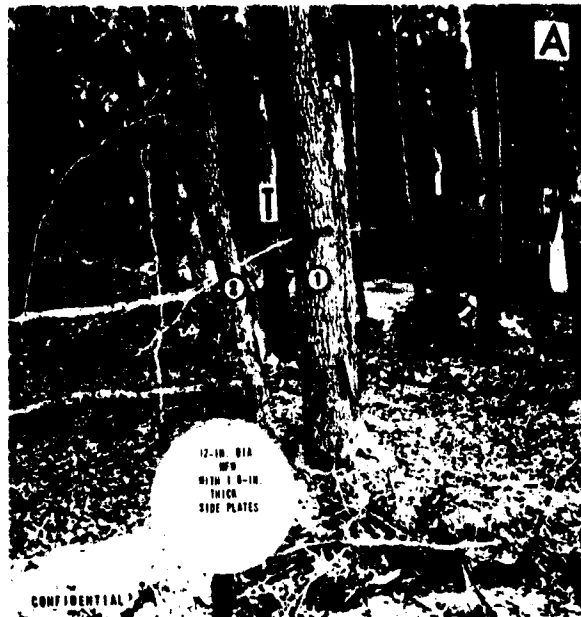
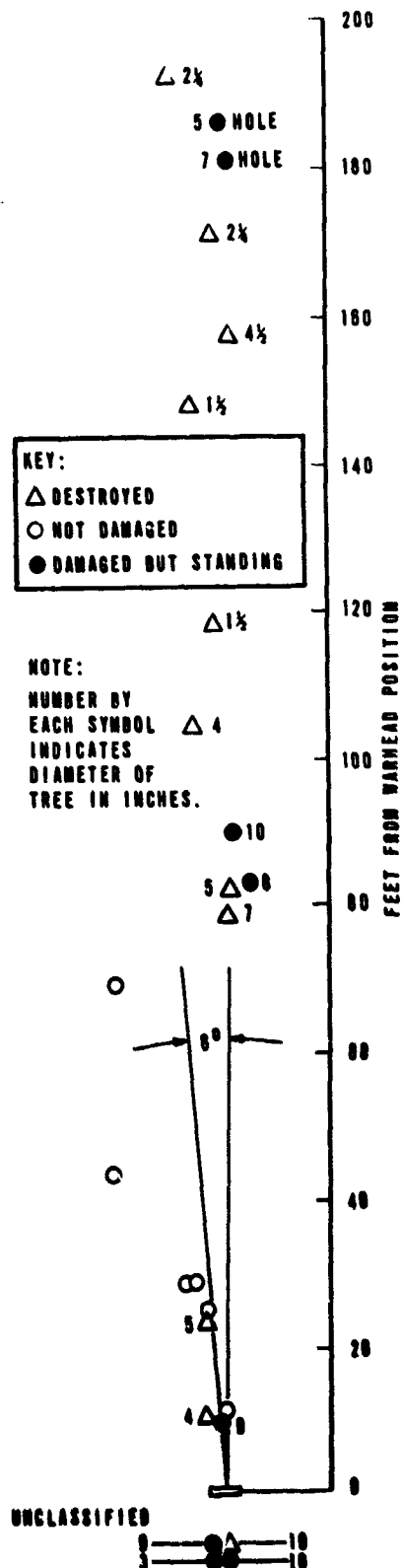


Figure 2 (Shot 14). View A shows a 12-inch MFW with 1/8-inch smooth sides aimed at target tree marked T. View B was taken from the same position after the shot. The trees marked \\\\\\\ were down before the shot. The stump of tree T is behind the stump of tree 2.

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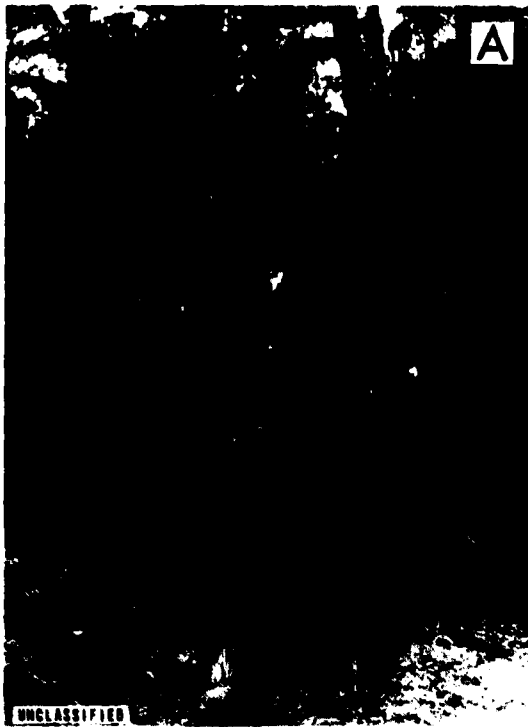


Figure 3 (Shot 14). View A shows 5-inch and 6-inch trees cut 78 feet from the warhead. View B is looking from tree T in Figure 2A at the warhead and the rear target which is shown in C (after). The warhead was aimed downward to the rear with intention of hitting the felled trees marked 2, but the tilt was excessive so that the target was cut at the ground and most fragments went into the ground. The stake which supported the warhead is marked 3.

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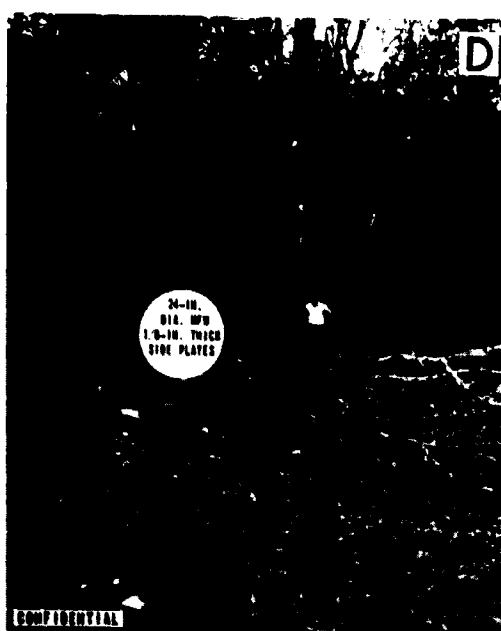
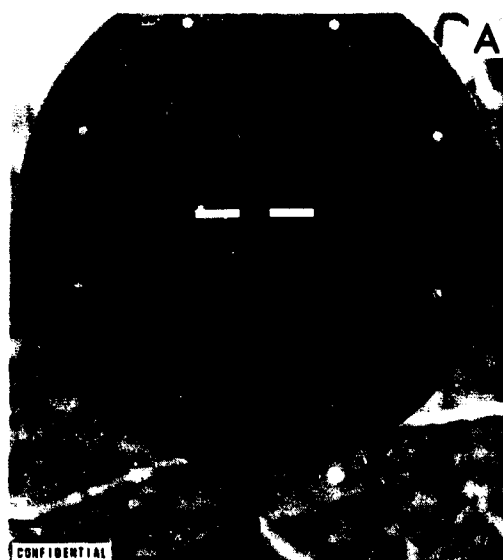


Figure 4 (Shot 13). View A shows .25 x .25 x .50 inch steel blocks glued to the side of a 24-inch-diameter warhead with 1/8-inch side plates. This side was aimed at the 19-inch gum tree shown in D (before) and in view B (after). The tree was 45.1 feet from the smooth side of the warhead.

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SECTION V

CONCLUSIONS

(C)(U) It is recognized that reliable conclusions cannot be drawn from 14 shots of which 12 were different test items. The following conclusions are tentatively reached:

1. The MFWs have a potential for tree cutting, and the 12-inch diameter with 1/8-inch thick face plates seems to be large enough to cut 12-diameter trees to at least 40 feet distance. While individual fragments punched through 5 and 7 inch trees beyond 180 feet, due to scattering, the effective range probably cannot exceed 50 feet. At 50 feet, fragments assumed to be 1/2 by 1 inch if uniformly distributed would be 1.5 to 2 inches apart.

2. The best claim that can be made from these tests is that 60 MFWs, precisely placed, would cut all trees up to 12-inch in diameter in a circle 100 feet in diameter. The warheads would weigh 1050 pounds.

3. While an array of MFWs might cut all trees in a 100-foot diameter circle, the trees would fall where they stood, leaving a tangle in which a helicopter could not land. The 450 pounds of explosive in 60 of the 12-inch MFWs would not have enough blast to blow the cut trees out of the area.

4. The MFWs tested are a first trial to find a weapon against trees. It may be assumed that considerable improvement is possible, even by cut and try methods. The present tests give no reason for further experiments with the conical series of warheads.

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SECTION VI

RECOMMENDATIONS

1. (C) Mass focus Warheads approximately 12 inches in diameter with 1/8-inch face plates should be tested in an arena to measure fragment distribution and velocity. Hardened steel side plates should be tested. Noncircular MFWs should be designed and tested in an effort to obtain a wide horizontal spread and a smaller vertical spread of the fragments.

2. (C) A combination blast and fragmentation bomb may be best for cutting and blowing away the trees.

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY	
13. ABSTRACT (C) Twelve different warheads having soft steel casings filled with type C-4 explosive were fired to cut down trees. Twelve-inch diameter mass focus warheads were effective over a 4-degree angle to 50 diameters range against trees up to 12-inch diameter. One 12-inch diameter Mass Focus Warhead [consisting of a 1-inch thick disc of explosive (7.5 pounds) between steel discs 1/8-inch thick (10 pounds)] cut all trees with maximum diameters from 5 to 9 inches within a 4 degree wedge to 80 feet from the warhead; it cut scattered small trees (2 to 4 inches) to 190 foot distance. Twenty-four-inch diameter MFWs were less effective (per unit weight) than the 12-inch designs tested. Six different hollow wall, double conical warheads were tested. These warheads had a shaped charge angle around their sides and were expected to project fragments in a sheet perpendicular to the axis. Actually, most of the energy was directed in the axial direction. These warheads made large craters and were ineffective against trees. A total of 14 shots were fired.		

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